On Watch

Vessel tracking technologies for maritime security.

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The United States' 96-hour notice of arrival data indicate that, on an average day, 1,040 vessels over 300 gross tons approach the United States from foreign ports, while another 350 ships are present in U.S. ports. An additional unknown number of vessels approach the United States and transit the exclusive economic zone on coastwise routes, bound for non-U.S. ports. These vessels are not required to send a notice of arrival, since they are not bound for U.S. ports and are not generally tracked. An estimated 5,000 of these large vessels are within 2,000 nautical miles of the United States at any time.

The Case for Vessel Tracking

The U.S. Coast Guard is faced with the responsibility of maintaining surveillance of maritime approaches to the United States for safety, security, and environmental protection. The economic impact resulting from just an 11-day loss of the use of a West Coast port has been estimated to be $140 million to $2 billion. Ongoing migrant and drug law enforcement efforts demonstrate the limited ability of U.S. civil government and military entities to see what is happening near the maritime borders.

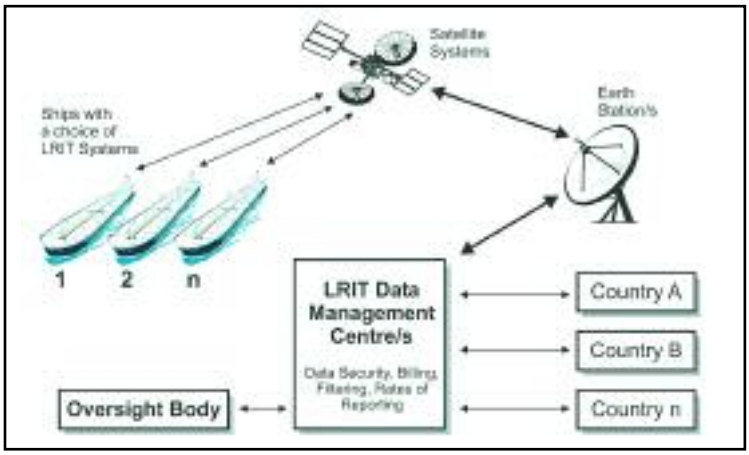

Figure 1: Long-range identification and tracking concept. Courtesy Inmarsat.

The Coast Guard is pursuing vessel tracking technologies to assist in the detection, classification, identification, and targeting of vessels. Among these technologies, automatic position reporting is being considered for tracking ships along the U.S. coastline, out to 2,000 nautical miles.

Long-Range Identification and Tracking

Long-range identification and tracking (LRIT) is a cooperative surveillance capability. In the LRIT concept (Figure 1), a ship carries radio communications equipment that reports identification, position, and time to authorities tracking that ship.

To improve maritime security in the near term, the Coast Guard may pursue voluntary LRIT. Ships subject to the Safety of Life at Sea Convention (SOLAS) and fitted with Global Maritime Distress and Safety Inmarsat-C equipment should have the capability to report position information. Many already use this capability or other satellite communications, such as fleet management systems, to report position and other information to shoreside agents and owners. Ship owners may be asked to voluntarily make their position information available to the Coast Guard electronically and permit polling.

LRIT and International Regulations Legislation
The Maritime Transportation Security Act (MTSA) of 2002 authorized long-range tracking to assist in maritime security: "The Secretary may develop and implement a long-range automated vessel tracking system for all vessels in United States waters that are equipped with the Global Maritime Distress and Safety System or equivalent satellite technology...."[1]

The Coast Guard and Maritime Transportation Act of 2004 amended this section of MTSA 2002 by requiring the implementation of long-range tracking, consistent with international treaties, conventions, and agreements to which the United States is a party.[2] More recently, pending legislation may call upon the Coast Guard to conduct a pilot project for long-range tracking using satellite systems to aid maritime security. [3]

With legislation as the underlying authority to implement LRIT, the Coast Guard is pursuing several regulatory initiatives at both the international and domestic levels.

Proposed Mandatory Participation for SOLAS Ships
The United States is leading the effort at the International Maritime Organization (IMO) for adoption of an LRIT SOLAS amendment that includes flag, port, and coastal state access to long-range identification and tracking information. The United States seeks to have SOLAS ships carry LRIT equipment capable of automatically transmitting ship identity, position, and time of position.

A U.S.-proposed draft amendment[4] to SOLAS Chapter XI-2 (Special Measures to Enhance Maritime Security) states that contracting governments, subject to certain restrictions, can receive LRIT information transmitted by ships as follows:

- Flag states: All flag ships worldwide.
- Port states: All ships indicating an intention to enter, at a distance or time set by the port state.
- Coastal states: All ships, regardless of flag, within a distance of 2,000 nautical miles of the coast.

The U.S. proposal was submitted to the IMO Maritime Safety Committee 78th session (MSC 78) in May 2004 but was not adopted. In December 2004, MSC 79 broadened the scope of LRIT beyond security, to include safety and environmental protection.[5] The IMO Radiocommunications and Search & Rescue Subcommittee (COMSAR) is developing LRIT performance standards and functional requirements and resolving other technical issues.

LRIT Study
During April and May 2005, the Coast Guard; the Republic of the Marshall Islands (RMI); and Pole Star Space Applications Ltd., an LRIT application service provider; conducted an LRIT feasibility study. RMI submitted its results to the IMO Maritime Safety

Figure 2: PurpleFinder Web-based display from the Marshall Islands LRIT Feasibility Study. Courtesy Pole Star Space Applications Ltd.

Committee 80th session (MSC 80). [6]

The United States acted as both port state and coastal state in this study. When the Coast Guard received a notice of arrival for a Marshall Islands ship, a request to track was sent to Pole Star. RMI ships that participated in this study were voluntarily tracked, even when not

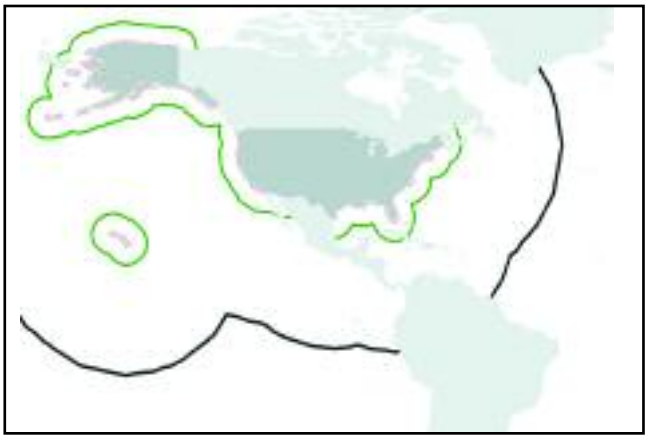

Figure 3: The 2,000 nautical mile and 300 nautical mile thresholds from the U.S. coasts.

bound for a U.S. port. Pole Star provided RMI ship raw data feeds, including IMO number, position, course, and speed reported, over Inmarsat-C. The Coast Guard Operations Systems Center processed this data and sent it to Coast Guard Command and Control Engineering Center to be integrated into the common operational picture. The position reports allowed the United States to track RMI vessels on the common operational picture and also via Pole Star's

Figure 4: Potential AIS coverage from NOAA data buoys.

PurpleFinder Web-based tracking tool (Figure 2). The feasibility study demonstrated to MSC 80 that long-range identification and tracking is achievable in the near term, from both technical and policy perspectives.

LRIT Regulations

At the conclusion of the IMO Maritime Safety Committee 80th session, officials agreed on the LRIT system architecture and minimum information requirements. It was agreed that the transmission of LRIT information should not require any intervention by shipboard personnel, will be at no cost to the ship, and will be available free of charge to contracting governments for search and rescue purposes. Only contracting governments that request and obtain LRIT information would be required to pay for the service.

MSC 80 officials also agreed that an independent long-range identification and tracking coordinator should perform oversight of the LRIT data center, application service providers, and elements of the communications systems. The LRIT coordinator should verify that all LRIT participants adhere to long-range identification and tracking information security requirements. The IMO Maritime Safety Committee requested the International Mobile Satellite Organization to advise the committee whether it was willing and able to undertake this oversight role. [7]

MSC 80 identified a number of LRIT key points:

- nothing in the regulation shall prejudice the rights or obligations of states under international law;
- the purpose of the regulation is for security, search, and rescue, and any other purpose as determined by IMO;
- the regulation applies to ships 500 gross tons and above;
- flag states can receive LRIT information from all their ships globally;
- flag states can name contracting governments that shall not receive LRIT information on their ships;
- port states can set either a time or distance for the mandatory receipt of LRIT information for ships bound for their ports;
- the distance at which a coastal state can receive LRIT information remains under discussion. [8]

An MSC intersessional working group meeting was held in October 2005 to develop draft SOLAS amendments on LRIT. Because an agreement could not be reached on coastal state access to LRIT information, the draft amendment only includes flag and port state access. The proposed amendment, submitted by the United Kingdom as Circular Letter No. 2681, dated November 8, 2005, is being circulated in advance of MSC 81 so that it might be adopted there. [9] At press time, COMSAR 10 is expected to complete work on long-range identification and tracking performance standards and functional requirements and forward these to MSC 81 for approval.

The deliberations at COMSAR 10 and MSC 81 on long-range identification and tracking performance standards and the draft amendment will have a significant positive impact on international maritime security. Figure 3 indicates the vast tracking area to which the United States will have access at the 2,000 nautical mile threshold (black line). This distance roughly equates to the 96-hour notice of arrival (at a ship speed of 20 knots.) The green line indicates the 300 nautical mile threshold.

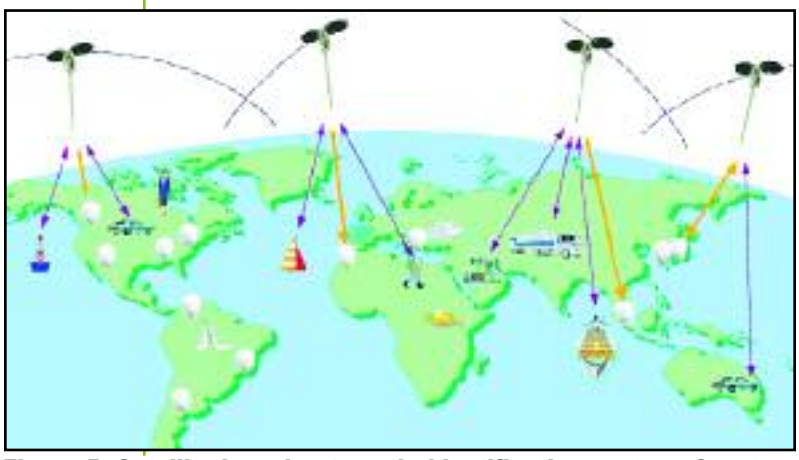

Figure 5: Satellite-based automatic identification system. Courtesy ORBCOMM.

Automatic Identification Systems

In addition to long-range identification and tracking for maritime security, automatic identification systems are also taking a role in the near-shore environment. An automatic identification system (AIS) is equipment required to be installed on SOLAS-class vessels effective July 2004.[10] AIS messages include a host of information such as ship identification, position, time, cargo, speed, and rate of turn. Although this system was designed for collision avoidance, by communicating information directly between ships within VHF range, AIS is now being used as a tool for maritime security.

Nationwide AIS

The Coast Guard is pursuing a major acquisition to deploy AIS receivers nationwide. In the short term, smaller scale efforts are being made in the Gulf of Mexico; in waters near Hawaii, California, and Alaska; and on offshore National Oceanographic and Atmospheric Administration (NOAA) data buoys. Figure 4 indicates the additional coverage that may be attained from these buoys.

Range of AIS Systems

AIS is a line-of-sight system, operating in the VHF band. A good rule of thumb for line-of-sight coverage is:

$$d=\sqrt{2h_{antenna}}+\sqrt{2h_{ship}}$$

where d is the line-of-sight distance (in miles) and h represents respective heights of shore and ship antennas (in feet). An AIS antenna on a tower at 300 feet should receive signals from a ship automatic identification system 30 feet above the waterline out to 32 miles. However, research has shown that AIS may reach much greater distances.

More comprehensive propagation models indicate a broader coverage area than the rule of thumb. Using the Engineer's Refractive Effects Prediction System-PROPR model, two ships with class A AIS antennas at 100 feet, 12.5 watt transmit power, 2.5 dB antenna gain, and receiver sensitivity of –107 dBm ought to receive each other at 40 nautical miles. From a similarly equipped ship to a shore station with 100-foot, 9.5 dB antenna gain and –119 dBm sensitivity, the shore station ought to "see" the Class A at 97 nautical miles. [11]

The Coast Guard Research and Development Center has established a network to study methods to improve AIS reception. Personnel conducted measurements on AIS shore site reception to determine apparent coverage area. At one typical site, 50 percent of the time, the maximum reception range was 140 nautical miles; 10 percent of the time the maximum reception range was 220 nautical miles. These distances are only achieved intermittently, but that may be good enough for security applications.

Although tower-mounted AIS may reach these distances, it is still limited in range. By placing AIS receivers at heights not achievable with towers, the capability expands to a significantly larger footprint.

Satellite-Based AIS

Coast Guard contracted with Johns Hopkins University Applied Physics Lab to determine if automatic identification system signals could be captured over a wide area, from a low-earth-orbit satellite. Because AIS transmissions are self-organizing, time division multiple access, vessels within the same horizon can broadcast their information in specific time slots, without stepping on each other's signals. This study examined the feasibility of receiving and deciphering a large number of simultaneous signals, with due regard to satellite receiver saturation. It showed that receiving automatic identification system signals at a satellite is feasible and a significant number of signals could be received simultaneously, without loss of message content. A contract was issued with ORBCOMM, a satellite data communications company, to put an AIS receiver on one of their satellites for testing. Figure 5 shows the satellite-based AIS concept. At this writing, the test satellite was due to be launched in 2006.

After validating the concept with a successful test, the Coast Guard plans to deploy a follow-on constellation. If testing of a satellite with an AIS receiver is successful, deployment could begin for a five-year phase in period to launch up to 26 satellites.

Through the use of technologies such as long-range identification and tracking and automatic identification systems, coupled with international regulations, the Coast Guard is striving to improve its maritime security stance.

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Endnotes

[1] 46 USC 70115.
[2] Coast Guard and Maritime Transportation Act of 2004, P.L.108-293, 118 Stat.1080.
[3] Coast Guard and Maritime Transportation Act of 2005, H.R. 889 section 404.
[4] IMO MSC 80/3/3.
[5] IMO MSC 79/23 para 5.72.
[6] IMO MSC 80/5/9.
[7] IMO MSC 80/24 para 5.98.3.
[8] IMO MSC 80/24 para 5.108.
[9] IMO Circular letter No.2681 dated November 8, 2005.
[10] SOLAS V/Regulation 19.
[11] Current Status of AIS Class B Development and Findings on AIS Signal Reception Range, David Pietraszewski and Joseph Spalding, 29 September 2004.